Space Weather Technical Forecast

Issued on Thursday, 05 January 2023 at 13:22 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of Moderate solar activity throughout. Chance of G1/Minor Geomagnetic Storm intervals on 5 and 6 January.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low, with occasional C-class flares, the strongest of these reaching C9.5 at 04/1845UTC due to a filament eruption in the vicinity of AR3177. This is one of five regions now on the visible disc. AR3181 has increased in areal extent with some spot emergence. AR3180 is stable but is the largest region on the disc and classified as beta-gamma. The new region AR3182 is considered to have been the source of the large CME from 3 January and currently classified as Hkx. Both AR3176 and AR3177 on the western hemisphere have decreased in growth and are both uni-polar. A CME from the southern hemisphere that left the sun on 2 January may impact Earth during the next 24 hours, but confidence is low.

Solar Wind / Geomagnetic Activity: Solar winds, observed at L1 started slightly elevated at 420km/s and following the CME passage have declined to slow-ambient levels around 360 km/s. Density produced a peak density of 28ppcc at 04/1400UTC, with values then staying above average for much of the period albeit with a slow decline. Total magnetic field strength exhibited the signs of a CME passage, with total magnetic field remaining at strong levels with a maximum of 20nT at 05/0344UTC, and then a decline thereafter. The north-south component Bz was mostly weak but fell sharply to moderate levels late in the period to reach -13nT at 05/1049UTC. Phi angle started positive (away from the Sun) until 04/1500UTC and has since been negative (towards the sun). Geomagnetic activity remained at Quiet to Unsettled levels.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2MeV) has been at background levels throughout. The 24-hour integrated electron fluence started just below the Active threshold with a falling trend observed and reached 3.85e6 integrated pfu by 05/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be mainly Low, with a chance of M-class flares through the forecast period.

Solar Wind / Geomagnetic Activity: The effects of a CME which arrived at Earth on 04 January are expected to continue to subside over the next 24 hours. A CME may glance the Earth on 05 or 06 January, but with low confidence. A possible combination of coronal hole high speed streams from coronal holes 60 and 61 are expected to connect with the Earth during 05 January, with speeds estimated to be reach 400-500km/s. Solar winds are likely to ease slowly by 07 and 08 January. There is a chance of G1/Minor Storms on 05 January, with these again possible on 06 January. A return to Quiet to Unsettled conditions are then probable through 07 and 08 January.

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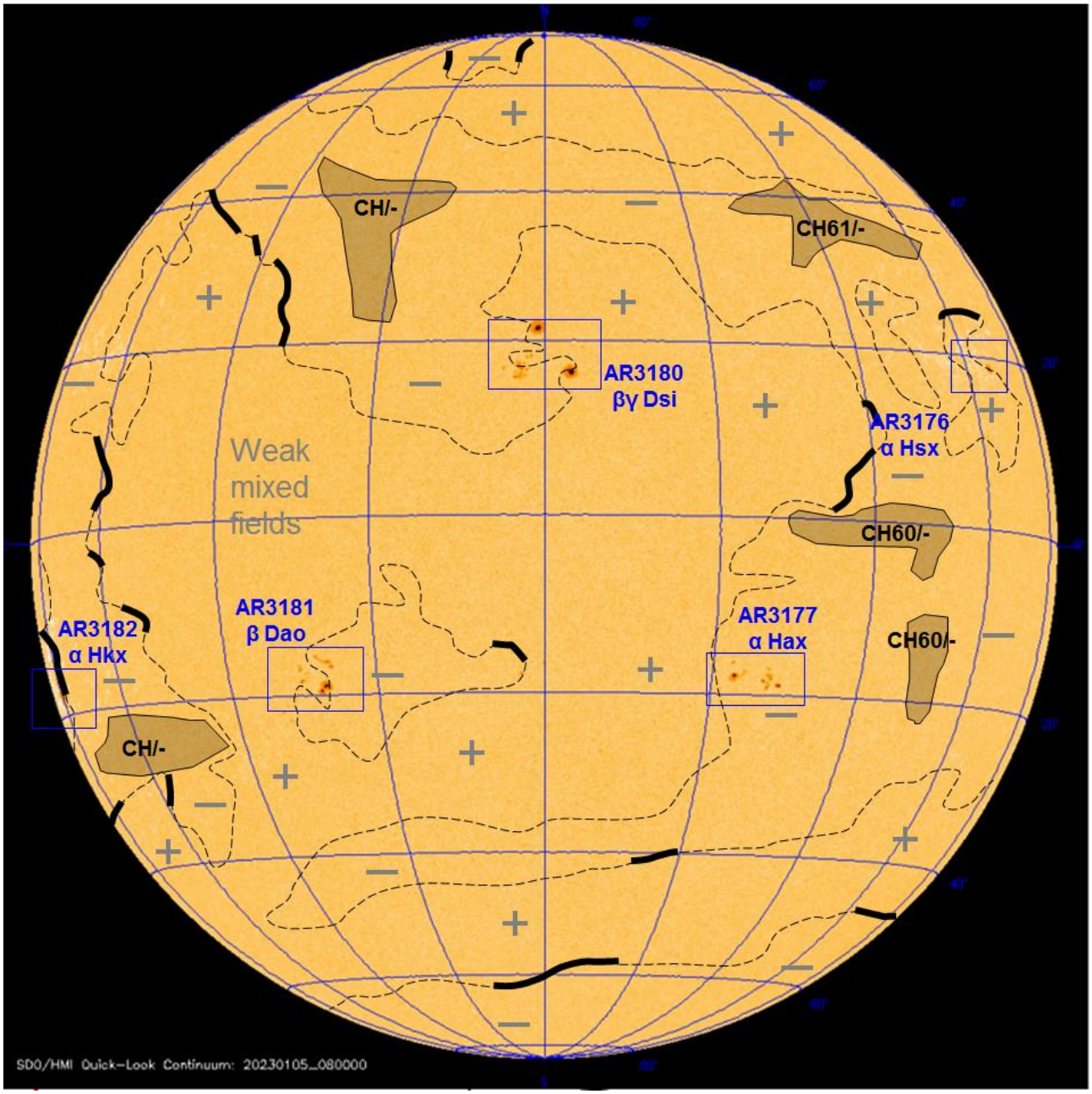
Met Office Space Weather Technical Forecast

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is expected to remain at background levels throughout with a chance of rising alongside any notable flares, giving a slight chance of exceeding the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) levels are likely to be suppressed during 05 and 06 January, with an increase then expected as the activity eases. Electron fluence values are forecast to remain below the Active (1e8 integrated pfu) levels for much of the period, with a slight increase in probabilities by the end of the period.

Figure 1. Solar Analysis Valid 0800UTC, 5 January 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME which left the Sun on 30 December impacted the Earth on 04 January with a clear signature observed on L1 data. A further glancing CME impact is possible either late on 05 or during 06 January from a CME which left the Sun on 02 January, but this carries low confidence. High speed streams from either coronal holes 60 or 61, or a combination of the two, are due to connect with Earth during 05 January, perhaps later in the day, based on evidence of a recent connection to a feature at STEREO-A, which could either be the coronal hole or a CME. Speeds of 400-500km/s are estimated from these coronal holes, which are much smaller than the equivalent features on the last rotation. These winds are then expected to slowly ease through the remainder of the period.

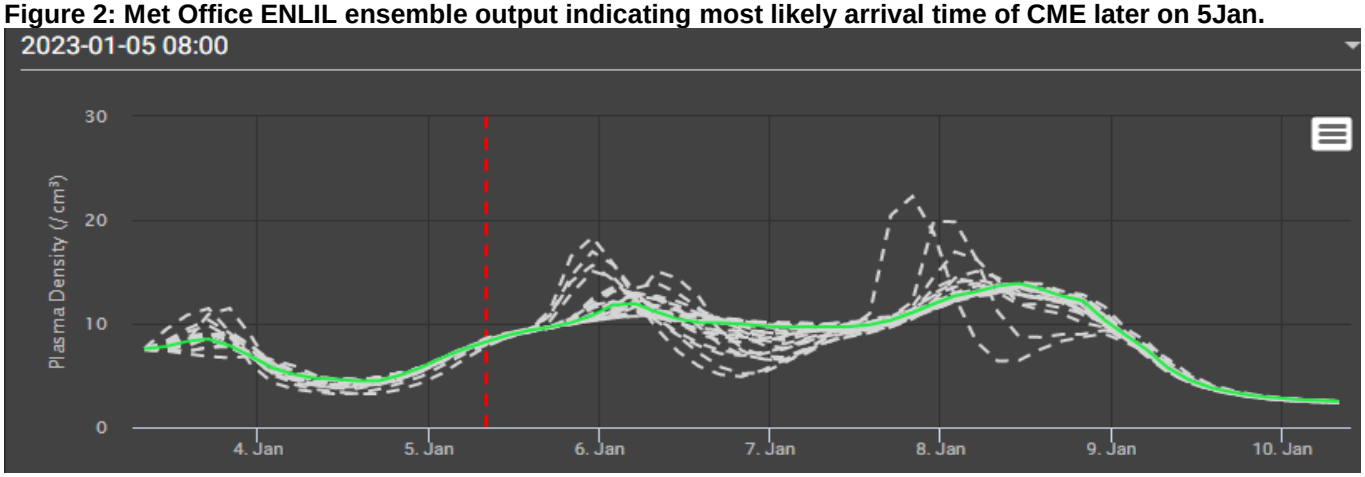
The geomagnetic activity forecast has a Chance of G1/Minor Storms on 05 January, with residual effects into 06 January, with a risk of further enhancements from a weak CME during the same period. A gradual return to mainly Quiet to Unsettled conditions are then forecast through 07 and 08 January.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	20	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
02/1454	Partial	Filament	SE	360	05/2000	Low confidence

Figure 2: Met Office ENLIL ensemble output indicating most likely arrival time of CME later on 5Jan.



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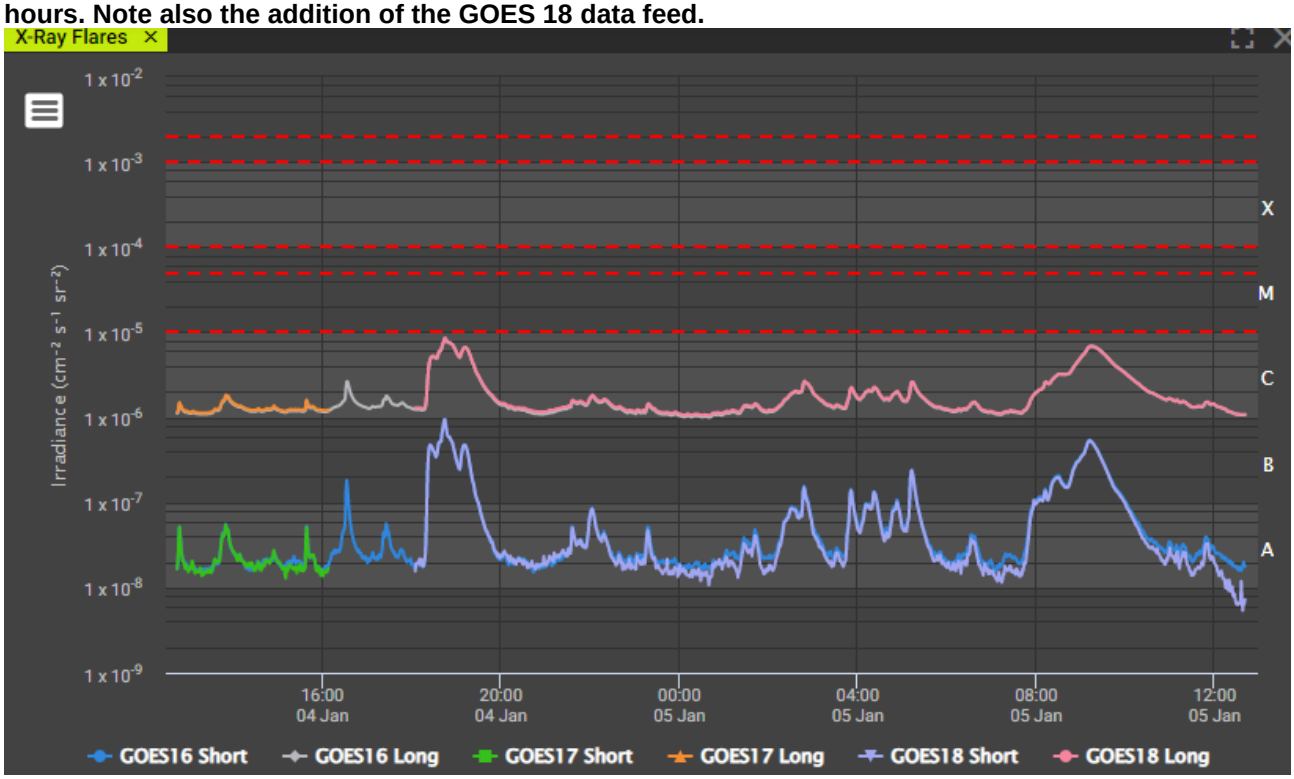
Radio Blackouts - X-Ray Flares:
There are five numbered sunspots on the visible disc with a relatively new (returning) active region that has rotated onto the southeastern limb, AR3182. This new region has been responsible for significant activity on the far side and contributes somewhat to an increase in flare probabilities through the period. AR3181 has increased in areal extent with some spot emergence. AR3180 is stable but is the largest region on the disc and classified as beta-gamma. The new region AR3182 is considered to have been the source of the large CME from 3Jan and currently classified as Hkx. Both AR3176 and AR3177 on the western hemisphere have decreased in growth and are both uni-polar. Solar activity is expected to be mainly Low, with an increasing risk of M-class flares, mainly from AR3180 near centre disc and resides in the northern hemisphere.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	50	50	50
Very Active	R3 to R5 X Class	No	5	10	10	10

Figure 3: X-ray flux plot at GEO from GOES showing the two most prominent C-class flares in past 24 hours. Note also the addition of the GOES 18 data feed.



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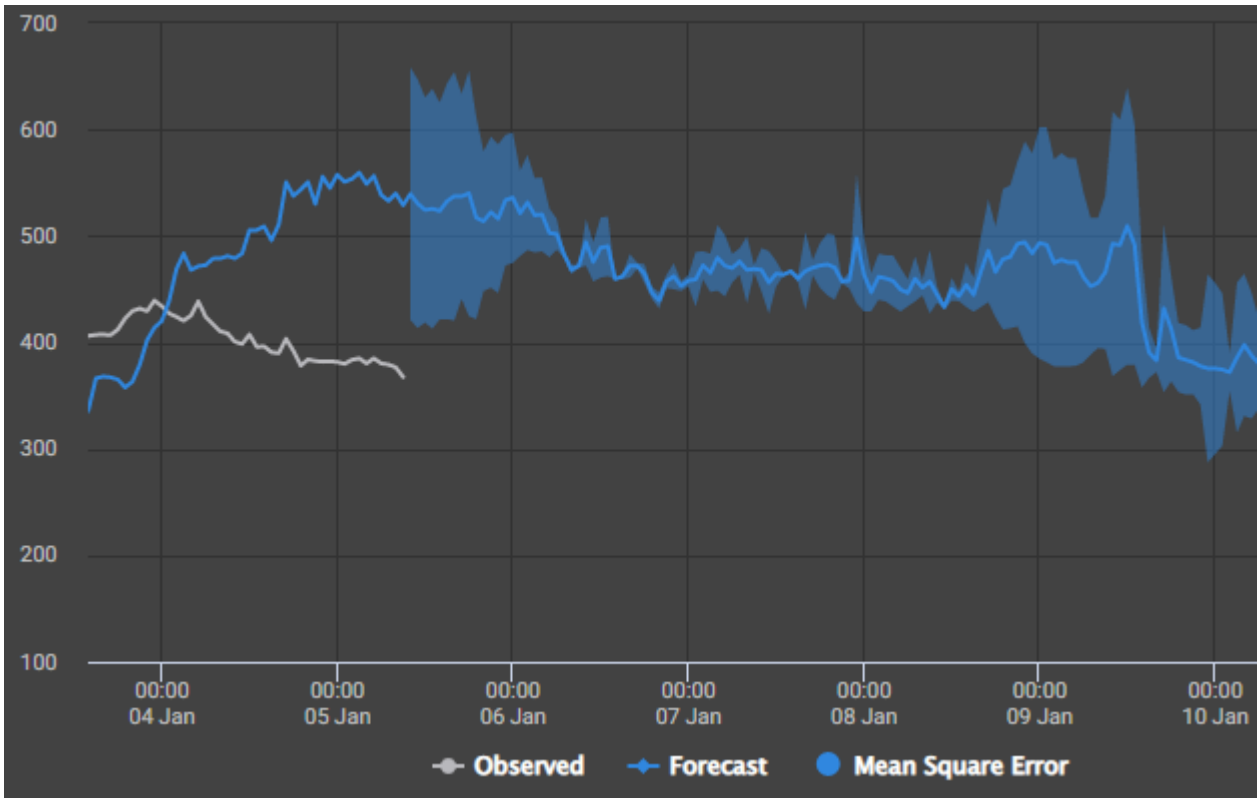
Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) measured by GOES-16 is at background levels. Any significant flares will bring a risk of proton flux rising at points during the period, with a slight chance of exceeding the S1/Minor Storm threshold. This risk increases slightly through the period, due mainly to the risk presented by the new region rotating onto the southeastern limb.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: Met Office Solar Winds Prediction Model (SWPM) indicating a general decline in levels over the guidance 4 day period.



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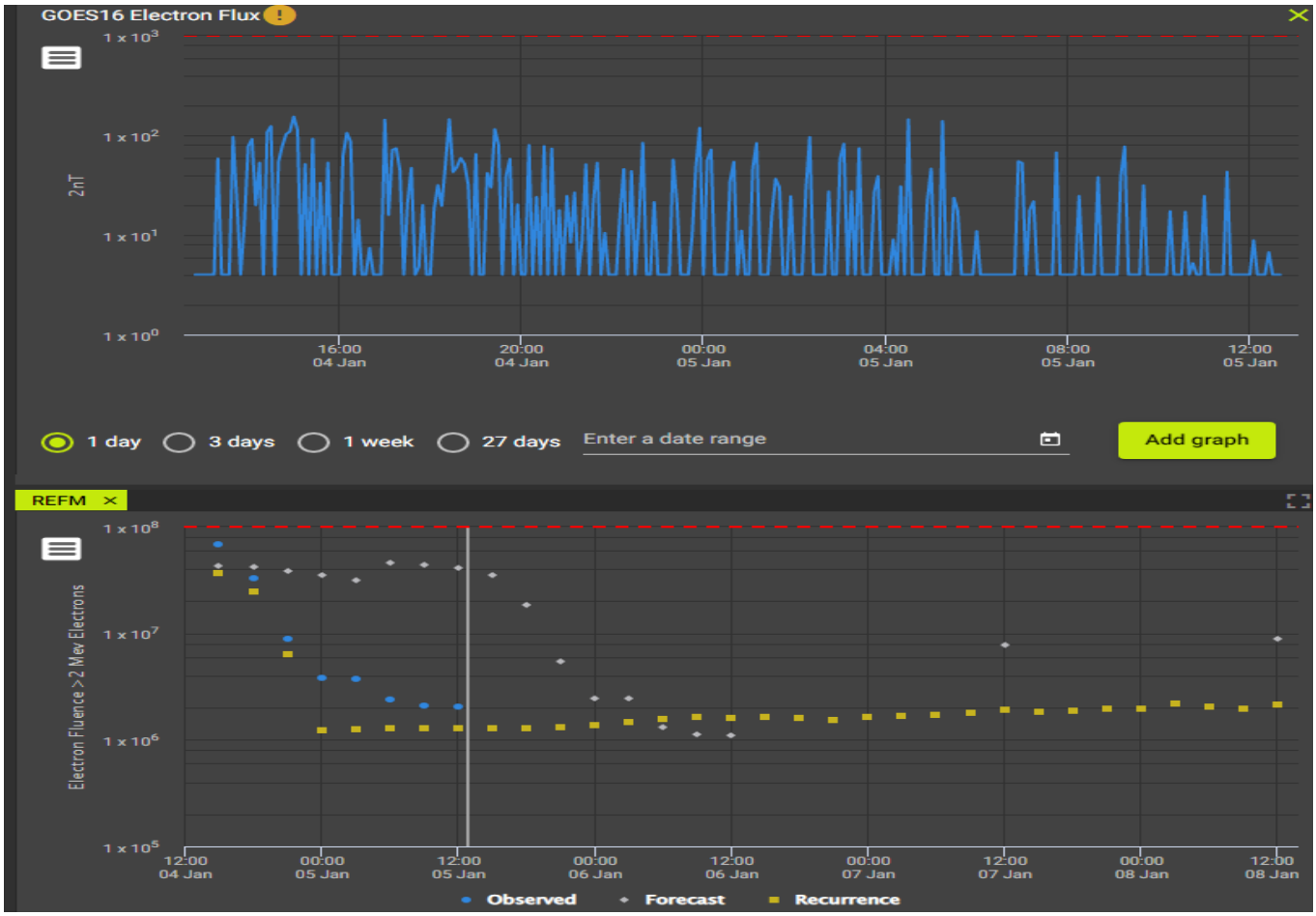
High Energy Electrons Event (≥ 2MeV):
Electron flux (greater than 2MeV) values have been at mainly background levels due to the recent impact and subsequent geomagnetic enhancements due to a CME arrival. The forecast connection to a coronal hole high speed stream is likely to further suppress electron flux values through 05 and 06 January. An increase is then likely through 07 and 08 January as geomagnetic activity subsides. Electron fluence is following a downward trend following recent geomagnetic activity. Electron fluence is not expected to now rise above the Active threshold during the period, with a slight increase in probabilities later in the period as geomagnetic activity decreases.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	10	10	10	20
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: High energy electron flux and Met Office REFM output guidance.



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